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5 **DUAL STAGE ACTUATOR SYSTEMS FOR HIGH DENSITY HARD DISK
DRIVES USING ANNULAR ROTARY PIEZOELECTRIC ACTUATORS**

FIELD OF THE INVENTION

10 The present invention generally relates to the field of piezoelectric devices and more particularly, but not by way of limitation, to an annular rotary piezoelectric actuator suitable for use as a secondary fine actuator in a dual stage head positioning servo system of a hard disk drive and to a dual stage actuator system for a high density hard disk drive using the annular rotary piezoelectric actuator.

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DESCRIPTION OF THE RELATED ART

Piezoelectric actuators have been used as positioners or driving motors in a broad spectrum of fields such as optics, precision machining, fluid control and optical disk drives due to their characteristics of small size, simple structure, quick response and, most importantly, controllable displacement down to nanometers.

In the area of hard disk drives, however, there exists a competition between micro machining electrostatic, electromagnetic micro actuators and piezoelectric actuators. The micro machining actuators are designed to drive the slider directly. An advantage of this type of actuator is its higher resonance frequency, but its stroke/voltage sensitivity is very small. The piezoelectric actuators, on the other hand, are commonly used to control the motion of the suspension. Compared with the former, the latter has a larger stroke/voltage sensitivity and a relatively lower resonance frequency. Unfortunately, the resonance frequency and stroke are of the same importance to the dual stage head positioning servo system of the hard disk drive. A piezoelectric actuator is disclosed in U.S. patent application serial No. 08/874,814 (U.S. Patent No. 5,898,544) filed on June 13, 1997 by Todd A. Krinke et al. entitled Base Plate-

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mounted Microactuator for a Suspension which is assigned to Hutchinson Technology Incorporated.

Regarding the piezoelectric actuator, for the purpose of decreasing the driving
5 voltage, d_{31} type multilayer, split-morph multilayer and II-beam multilayer are presented as the secondary fine actuators of the dual stage servo system. However, the conflict of resonance frequency and stroke still remains unresolved.

In the present invention a micro machining piezoelectric actuator used to drive the
10 slider directly is proposed to meet the requirements of resonance frequency and stroke simultaneously.

SUMMARY OF THE INVENTION

15 A general object of the present invention is to provide a new structure of piezoelectric actuator which has a function of generating rotary deformation around its shape center.

A specific object of the present invention is to provide a piezoelectric actuator
20 which can be used as a secondary actuator in a dual stage servo system of a hard disk drive.

A more specific object of the present invention is to provide a piezoelectric actuator which can be mounted between the suspension and the slider to drive the
25 magnetic pole tip of the slider to move across data tracks so as to obtain a head positioning servo system with high bandwidth.

Yet another specific object of the present invention is to provide a piezoelectric actuator which has a symmetric configuration and a simple potting process so that it
30 can be easily manufactured and realized in a head gimble assembly (HGA).